

# AirCargoChallenge 2021

# Participation Handbook

Version 01.00

06.08.2020



# Introduction

---

The Air Cargo Challenge (ACC) is a competition aimed at engineering students. It was created to excite students for aviation and to experience the challenges of an engineering task. Within 10 months, an unmanned aircraft is designed and built to compete against other teams from all over the world. The main task of the aircraft is to transport a payload. The AkaModell Munich successfully competed against 27 other teams in the Air Cargo Challenge 2019. As the winner of the competition, we are organizing the next event in the summer of 2021 in Munich.

## About Akamodell Munich:

We are a club of engineering and aerospace students at the Technical University of Munich, founded in 1999. We do basic research, theoretical development, design, construction and finally flight testing of remote-controlled model aircraft. Our goal is to supplement the education of students at TU Munich by successfully applying our theoretical knowledge to practical problems. In the last 21 years we designed 19 "official" aircrafts. Some of them can be built for private flying and gained a big interest within our group.

# CONTENTS

---

Introduction .....	3
1 Notification, News and Contact .....	7
2 Corona information.....	8
3 Organization Handbook.....	9
3.1 Nomenclature.....	9
3.2 Participation.....	10
3.3 Application.....	10
3.4 Financial .....	11
3.5 Euroavia .....	11
3.6 Competition Program.....	12
3.7 Insurance and Accidents.....	13
3.8 Deadlines .....	13
3.9 Jury .....	14
3.10 Location & Program .....	14
4 Regulations Handbook .....	15
4.1 Nomenclature.....	15
4.2 Flight goals .....	15
4.3 Flow Chart of the Flight Competition .....	16
4.4 Aircraft .....	17
4.4.1 General .....	17
4.4.2 Transportation Box.....	17
4.4.3 Size restrictions.....	17
4.4.4 Identification .....	17
4.4.5 Propulsion.....	19
4.4.6 Radio Requirements.....	21
4.4.7 Autopilots.....	21
4.4.8 Automated Measuring Equipment .....	21
4.4.9 Payload.....	22
4.4.10 Maximum take-off weight.....	22
4.4.11 Longitudal Stability of the Aircraft.....	22
4.4.12 Aircraft Production .....	23

4.4.13	Proof of Flight.....	23
4.4.14	Technical Inspection .....	23
4.4.15	Static Load Test.....	24
4.5	Deliverables .....	25
4.5.1	Preliminary Report (PR) .....	25
4.5.2	Technical Report (TR).....	25
4.5.3	Drawings .....	26
4.5.4	Video Presentation (VP) .....	26
4.5.5	Proof of Flight Video.....	27
4.5.6	Poster .....	27
4.5.7	Deliverables Scoring .....	27
4.6	Competition .....	28
4.6.1	Flightfield.....	28
4.6.2	Flight area .....	28
4.6.3	Bad weather .....	28
4.6.4	Protest .....	28
4.6.5	Pilot, Helper and Flight Manager.....	29
4.6.6	Overview of entire flight task .....	29
4.6.7	Take-off .....	29
4.6.8	Restricted areas.....	30
4.6.9	Flight Pattern .....	30
4.6.10	Landing.....	30
4.6.11	Minimum flight altitude .....	30
4.7	Flight Competition Scoring .....	31
4.7.1	Overview .....	31
4.7.2	Partial Scores .....	32
4.7.3	Payload Scoring.....	32
4.7.4	Distance Scoring.....	32
4.7.5	Altitude Scoring.....	33
4.7.6	Definition Flight Time .....	34
4.7.7	Loading Time.....	34
4.7.8	Unloading Time .....	34
4.7.9	Payload Prediction Bonus.....	34

- 4.7.10 Take-off Bonus..... 35
- 4.7.11 Flight Penalties..... 35
- 4.7.12 Score for one Round..... 35
- 4.7.13 Score for the Flight Competition..... 35
- 4.8 Global Penalties..... 37
- 4.9 Total Score / final Ranking..... 38
- 5 Final remarks..... 39
- 6 Appendix..... 40
  - 6.1 Transportation box..... 40
  - 6.2 Limiting Box in set-up state..... 41
  - 6.3 Automated Measuring Equipment..... 42
  - 6.4 Payload Photos / Dimensions ..... 43
  - 6.5 Flightfield photos ..... 48

# 1 NOTIFICATION, NEWS AND CONTACT

---

All news will be posted on our website [www.acc2021.de](http://www.acc2021.de) .

We suggest visiting the website regularly. This is the binding source for news as well as changes in the regulations and organization.

For press inquiries please contact [info@acc2021.de](mailto:info@acc2021.de) .

Some updates will be announced additionally on our Facebook page ([www.facebook.com/akamodell](http://www.facebook.com/akamodell)).

If you have any questions concerning regulations or organization, please contact [teamcontact@acc2021.de](mailto:teamcontact@acc2021.de).

PLEASE use your team number and team name as first words in the subject line. (e.g. "04 Akamodell Munich - Question about motor")

This contact is for all questions by the teams (organizational, financial, regulations, etc.).

If necessary, the answers will be made public to every team.

There will be two WhatsApp groups:

1. "ACC2021 all Participants": for all participants (unmoderated) to increase the communication between the teams before the competition. You will get the invitation link after your registration. All team members may join. Don't expect us to read all posts!
2. "ACC2021 team leaders": for team leaders only! You may ask questions regarding Organization or Regulations. Please keep this group short and informative. Please use this only for small inquiries, everything else via e-Mail. ([teamcontact@acc2021.de](mailto:teamcontact@acc2021.de))

The competition regulations may be changed by the organizing committee in order to fix errors or omissions that are found in the existing regulations. The organizing committee may contact the team leaders by e-mail about more or less urgent subjects. All teams are considered to be notified from the moment the information is available at the official website of the competition.

## 2 CORONA INFORMATION

---

The current situation is very special. The corona virus pandemic costs a lot of lives around the world and we still don't know how long the restrictions will be in place or how they will look like in 2021. Travelling between countries, even inside the EU, is at least difficult. Additionally, the economic crisis puts pressure on a lot of companies. This leads to a difficult search for sponsors.

There are a lot of problems and challenges that still lie ahead of us. We are closely monitoring the situation and will adapt to changes if necessary.

1. Most important: we do not want to endanger any participant by being with us in Munich!
2. The travel restrictions won't be in place forever. Our main concern is for the European countries, but we know that usually there were some teams from all around the globe. There must be a high probability that no team within the EU has problems getting to Munich and back home safely.
3. Our goal is to connect you with other participants. Being in direct contact and exchanging ideas is the main factor for a good ACC. This will not be possible while maintaining save distance between everybody.
4. Finding sponsors is difficult at the moment. To reduce your cost we added some more restraining rules about the aircraft size. This should have a significant financial impact for you.

It should also reduce the need for a big workshop. A lot of model aircrafts are built on the kitchen table. Let's be creative!

We thought long about delaying the ACC for one year "until the dust settles". But since we believe in a positive Corona development, we want to go ahead like planned and hope that we will be able to enjoy a great ACC 2021!

But what if it won't be possible?

We do have two dates to decide if we postpone the competition.

First option is the end of 2020. Depending on how many teams applied for the competition, we will decide if it makes sense to postpone the ACC for one year.

The second option is to cancel it in 2021, up to 3 months before the competition. Wherever possible, we organized a cancelation policy to allow this. At the moment we do not think that you would have any financial drawbacks. Only one more year to optimize and build... ;-)

Nevertheless, in case of a very unlikely complete cancelation, we can only pay back money that we are getting back as well.

In case of delaying the competition for one year, **all your registrations would remain valid**. If there were any drop-outs or the team limit was not reached before, there might even be a new additional registration period one year later.

## **3 ORGANIZATION HANDBOOK**

---

Section 3 of the handbook will deal with all organizational matters.

The technical parts of the competition will be in Section 4. Regulations Handbook.

### **3.1 NOMENCLATURE**

Shall = this is a requirement that should be kept. Please consult with us EARLY if you can't realize any of these rules to find a solution.

Must = this is a hard rule. Not keeping it will definitively lead to a penalty or up to disqualification!

## 3.2 PARTICIPATION

A team consists of 4 to 7 people. All team members shall be over 18 years old during the competition.

One team member is the designated pilot. If you don't have a pilot, please contact us before applying.

The pilot may be a "non-student". (e.g. pilot at your local RC-club,...)

Except for the pilot, all other team members shall be students, professors or research associates of the higher education institution that they are representing.

In case the organizing committee finds some of the team members are not from the university or other irregular actions occurred, the team will be disqualified.

Teams not representing higher education institutions or from universities outside Europe may be accepted by the organizers. European teams will have priority.

A professor in charge is required when the team represents a university or different higher education school. He may also be a team member. A written declaration is required in which the professor states that the team is representing the university and confirms that all team members are students or employees of the university.

## 3.3 APPLICATION

The application period will begin on September 1<sup>st</sup> and will close on November 1<sup>st</sup> 2021.

The application form can be downloaded during this period on [www.acc2021.de](http://www.acc2021.de).

We have to stop the application, if 30 Teams have applied. If the limit is exceeded, the application will be accepted in a first come first serve manner. Every team is allowed to participate with a maximum of 7 team members. Due to this limitation there are no guests possible in the initial application. If we still have free capacities after November 1<sup>st</sup>, it might be possible to bring guests and additional team members. Otherwise everyone is free to visit the ACC as a visitor. Each university can participate with one team. The application is valid after the organizer receives the following items:

- Application is fully and correctly filled out
- Copies of documents proving that all team members are eligible (ex: Student card, etc.)
- Professor in charge statement

All this information must be sent to [teamcontact@acc2021.de](mailto:teamcontact@acc2021.de) with the declaration of the team name in the subject line of the e-mail. (e.g. "Team Daedalus – Application")

Applications made before 01.09.2020 00:00 UTC or after 01.11.2020 24:00 UTC, will not be accepted.

The teams will be contacted via e-mail after processing, to confirm successful registration. A provisional list of the teams will be published one week after the application stop.

You will get a bill after the application with important information like IBAN,...

The application will become effective with the first bank transfer of the team application fee.

### 3.4 FINANCIAL

The first transfer has to take place until February 1<sup>st</sup> 2021 with 100€ per team member. Please use your team number and the name of your university as reason of payment. The second transfer has to be made until the 1<sup>st</sup> of April with 150€ per team member. Banking fees have to be covered by the participating team. We can only process received funds.

<b>Transfer</b>	<b>Amount per team member</b>	<b>Deadline</b>
<b>1<sup>st</sup></b>	100€	01.02.2021
<b>2<sup>nd</sup></b>	150€ (additional)	01.04.2021

AkaModell München e.V. will make all efforts in order to provide the teams the greatest comfort and support possible.

Accommodation, meals and transportation during the competition are provided in the application fee.

Each member, including the pilot, must pay the application fee. The fee for the team members does not cover all expenses of the organizing committee. The deficit will be covered by sponsoring. We are still trying to reduce the amount of the second payment through additional sponsors. In case of a cancelation we will try to give back as much money as possible.

The teams are responsible for fulfilling all application fee deadlines.

### 3.5 EUROAVIA

We were asked by Euroavia IB if we could report what local EA groups join the ACC2020.

We are happy to help EA to continue the Air Cargo Challenge in the future and will report Euroavia IB what EA groups registered for the competition.

### 3.6 COMPETITION PROGRAM

The competition will take place in Munich on 6.7.2021 - 9.7.2021.

This is a preliminary schedule. At this point in time there is some uncertainty regarding the third competition day (Friday). We will update the schedule regularly and release the final version via our website.

Timetable (preliminary):

Day	Mon	Tue	Wed	Thu	Fri (optional)	Sat (Fri)
Date	5.7.21	6.7.21	7.7.21	8.7.21	9.7.21	10.7.21
Morning		Technical inspection, Poster session	Test flights	Competition flights Day 2	Competition flights Day 3	Departure until 9:45!
Afternoon	Arrival Check in beginning 14:30	Technical inspection, Poster session	Competition flights Day 1	Competition flights Day 2	Competition flights Day 3	
Evening	NO dinner!	Dinner	Dinner	Dinner	Final Dinner	

You may check-in on Monday between 14:30-20:00 at the hostel. For later arrival, please check with us before the competition.

Check-out on Saturday is 9:45 latest!

Since all meals are pretty expensive and we don't know exactly when you will arrive in Munich, we decided that there will be no dinner on Monday!

This means, if you arrive late, have a sightseeing tour, sleep,... you may eat wherever and whenever you want. We will provide you with a list of less expensive locations in Munich. If there is enough demand, we try to organize a reservation in Munich. (Not included in the participation fee, more details will follow)

### 3.7 INSURANCE AND ACCIDENTS

The pilot needs to have insurance for model airplanes by German law. It must cover at least 1.000.000 €. Every pilot is responsible for his aircraft during flight. **IF** the pilot is required to complete a proof of competency certificate, we will tell you early enough.

We advise all participants to travel with health insurance and with a European card of medical assistance.

### 3.8 DEADLINES

The important deadlines for the participation are summarized in the table below.

Application period	01.09.2020 12 UTC – 01.11.2020 24 UTC
First bank transfer	01.02.2021
Second bank transfer	01.04.2021
Preliminary report	01.03.2021
Technical report and drawings	01.05.2020
Video presentation and proof of flight video	21.06.2021
Competition	06.07.2021

#### ***3-1 Important Deadlines***

### **3.9 JURY**

The jury consist of university professors, industry representatives and members of AkaModell Munich. They will be announced in the near future. They will score the reports and videos submitted by the teams.

### **3.10 LOCATION & PROGRAM**

This section will be filled later with general information about our location and program.

## 4 REGULATIONS HANDBOOK

---

### 4.1 NOMENCLATURE

Shall = this is a requirement that should be kept. Please consult with us EARLY if you can't realize any of these rules to find a solution.

Must = this is a hard rule. Not keeping it will definitively lead to a penalty or up to disqualification!

We consider the ACC regulations as “open”, meaning that everything that is not forbidden is allowed. Of course this is limited by safety concerns. If you are not sure about something you thought of, you can always contact the organizer to clarify if it is allowed.

The powertrain providing thrust to your aircraft is “closed”, giving only a limited number of options to provide fair and equal conditions for every team.

### 4.2 FLIGHT GOALS

This year the rules for the ACC changed significantly. This has several reasons:

- We wanted smaller aircrafts that are cheaper and faster to build (hopefully)
- Less dependence on the skill of the pilot (no sharp turns)
- Less benefit for vast computing power, more engineering practice
- Automated measurement of flight data
- New challenge for existing teams
- Adaption to real life scenario

Your task is to transport medical emergency goods from one point to another.

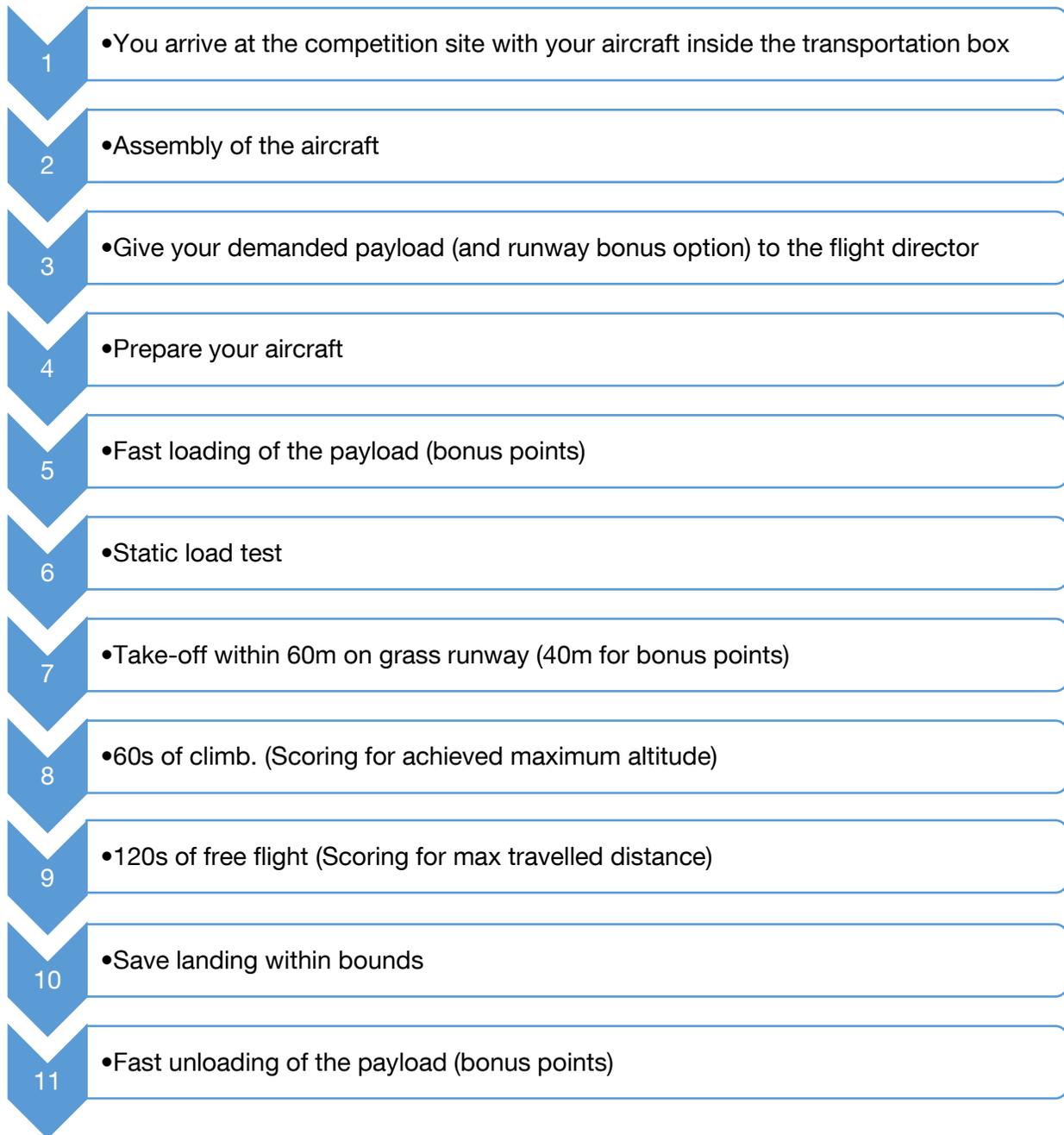
Imagine an avalanche or a flood cutting off a village. You need to transport medical supplies to and from a laboratory fast and environmental friendly. In our case, we use blood bags as payload.

There are several demands for your aircraft:

1. Transport as much as possible...
2. ...and as far as possible within two minutes.
3. After take-off you have to get to a safe altitude as quick as possible to avoid obstacles
4. You only need little space for transport, assembly and take-off

The first three demands are being scored during the competition.

### 4.3 FLOW CHART OF THE FLIGHT COMPETITION



Now that you are familiar with the competition sequence we will get into the details. Let's start with the aircraft.

## **4.4 AIRCRAFT**

### **4.4.1 General**

You are tasked to design an aircraft which is powered by an electric propulsion device and which generates lift by aerodynamic forces acting on surfaces remaining fixed in flight, except control surfaces. Aircraft with variable geometry or area must comply with the specification when the surfaces are in maximum and minimum extended mode. The remotely piloted aircraft must be controlled by the pilot on the ground using radio control. Any variation of geometry or area must be actuated at distance by radio control.

The aircraft must not be rotary wing or lighter-than-air (for example, helicopters, autogyros, dirigibles and balloons are excluded). No form of externally assisted take-off is allowed. All energy for take-off must come from the on-board propulsion battery pack(s). The only means of aircraft propulsion is the prescribed electric motor.

### **4.4.2 Transportation Box**

Each team must use a transportation box for the aircraft. The box is limited in size and must not exceed 1100 x 400 x 250 mm<sup>3</sup> (inside dimensions, 6.1 Transportation box). All parts of the aircraft (wing, tail, fuselage, landing gear, motor, propeller...) must fit into this box at one time. The transmitter is not regarded as a part of the aircraft. The batteries must be transported in a special protective container. (See Section 4.4.5) The Transportation box must be used during the transfer between the hostel and the airfield and is also well suited to travel as luggage in an airplane. It is also recommended that each transportation box must have handles on both ends.

### **4.4.3 Size restrictions**

The size of the assembled "flight ready" aircraft must fit into a four-sided box with an edge length of 1.5m each. The angle between the edges is NOT fixed! You may vary them as you want.

The maximum height is 0.5m. (Standing on the floor by itself (e.g. in take-off configuration), no additional support)

See Section 6.2 Limiting Box in set-up state

### **4.4.4 Identification**

Every aircraft must have unique identification symbols. This identification shall be the team number and the name of the university. Other logos, for example from sponsors, are also allowed.

The team number must be visible on the aircraft:

- In figures with at least 10cm height (if this is not possible, please contact us)
- On both top and bottom of the wing
- On both sides of the fuselage or vertical stabilizer.

The university logo shall be visible on the wings or the fuselage. The university initials can be used if they are unique and recognizable or the logo is too complex.

By German law you must have a fireproof sticker or metal plate visible from the outside. Your name and postal address (e.g. Owner/Pilot)

The plate must be screwed or glued to the aircraft.

Example:

<https://www.shop.deutscher-modellflieger-verband.de/Flugmodelle/Kennzeichen-fuer-Flugmodelle.htm?shop=dmfv&SessionId=&a=catalog&t=5&c=197&p=197>

or

<https://shop.vth.de/flexible-kennzeichnungsschilder-fur-flugmodelle-5-stk-6211734/>

#### **4.4.5 Propulsion**

To ensure fair and equal conditions during the competition, certain parts of the powertrain are prescribed for all teams.

Only the prescribed parts are allowed in the powertrain. All parts have to be "commercially, off the shelf", in unmodified condition.

##### **Propeller**

It is allowed to use one propeller on the aircraft. The participants may choose between two variants:

- APC-E 10x6E Manufacturer code: LP10060E or LPB10060E  
<https://www.apcprop.com/product/10x6e/>
- Aeronaut CAMcarbon Light 10"x6" Manufacturer code: 7216/22  
<http://www.aero-naut.de/produkte/flugmodellbau/flugzubehoer/luftschrauben/camcarbon-light-prop/>

The propeller has to be fastened to the power train in a secure way (photograph/drawing in the final report). A common motor spinner or airscrew nut is ok (e.g. the one shipped with the motor).

The propeller must be demountable to allow a test run without propeller during technical inspection.

##### **Transmission**

The rotational speed of the propeller must always be the same as the rotational speed of the motor.

-> e.g. only 1:1 Gears are allowed as long as they keep the motor rpm unchanged toward the propeller.

##### **Motor**

The motor must be an unmodified "AXI 2826/10 GOLD LINE V2" (Please note that the old V1 is no longer included to ensure that all teams can get the same motor).

The aircraft must be driven by a single motor. The motor is fixed to the airframe of the aircraft.

The motor must be easily accessible from all sides to allow for inspection.

You may solder the motor to the ESC or use plugs.

##### **ESC**

You may use your choice of ESC with minimum 30A constant current rating. Only commercial ESC available to everyone are allowed. The ESC is not allowed to increase the voltage of the battery in any way.

**Main Battery:**

You may use LiPo, Lilo or LiFePo based batteries. You may use up to 3 cells in series. The maximum voltage for the pack is 12.6V (Lilo and LiFePo have a lower maximum Voltage, according to their datasheet). The maximum continuous discharge rate has to be at least 30A. The maximum voltage per cell as specified in the datasheet must not be exceeded.

Voltage, capacity and maximum discharge rate shall be clearly printed on the battery. The cells/packs must keep their factory look and may not be altered except for the plugs. If the required data is not printed on the pack/cells you must provide the datasheet from the manufacturer.

Be careful with Lithium batteries, they can be dangerous. Also check with your airline on how to transport them. (<https://www.rcgroups.com/forums/showthread.php?209187-Complete-Guide-to-Lithium-Polymer-Batteries-and-LiPo-Failure-Reports>)

The batteries must have a minimum capacity to ensure the planes can perform at least one flight pattern. However, each team can choose to use batteries with larger capacities (in case a second start is necessary or for other reasons).

Each team is responsible to have their batteries charged before each flight. It is recommended to bring more than just one battery.

All batteries have to be stored and transported in a LiPo safety bag or container and not mounted in the aircraft. Usually you can buy these safety bags at your LiPo battery dealer. If you notice a damaged LiPo battery, notify the organizational committee immediately!

**Not confirmed yet: At the airfield, electric power (230V AC German plug and 12V DC) will be available in order to enable the teams to charge their batteries.**

**Connectors**

There are no restrictions according connectors. The connector must have a constant current rating of at least 50A. We recommend XT60/XT90 plugs between battery and ESC. This might also allow for cross compatibility with other teams if you encounter a defect. If you deviate from XT60/XT90, the connectors have to pass the technical inspection.

The connection between ESC and motor may be realized by connectors or soldering.

#### **4.4.6 Radio Requirements**

The radio control is used to fly and operate the aircraft. The servos have to be capable to withstand the aerodynamic loads the aircraft is going to be subjected to during the flight. The flight will occur at any given weather conditions as long as the limits given in chapter 4.6.3 are not exceeded, either sunny, rainy or windy. Therefore the teams shall be prepared to protect their radio equipment.

All radios must comply with the frequencies for model aircraft in Germany. An independent RX battery pack is mandatory, with a minimum capacity of 600 mAh (2s LiPo recommended). No power supply from the main propulsion battery (Battery eliminating Circuit, BEC) is allowed. If your ESC has a BEC, you have to disconnect the positive wire to the RC system or use an optocoupler module.

Only 2.4GHz Systems are allowed, since it reduces the risk of multiple teams having the same frequency channel. Please be aware that with some manufacturers your radio must have an EU firmware installed to comply with German radio regulations. (e.g. Taranis EU Firmware)

Please read the manual on how to put the transmitter into range-check mode.

The fail-safe function in the receiver must be activated: at least Motor OFF!

We try to organize a radio link from the aircraft (Automated measuring Equipment) to the ground. If it works, we can see the position of the aircraft and directly show a preliminary score for the flight. We will use a 434MHz or 868MHz Radio for this task. Please place your RC receiver antennas in some distance to the measuring box to avoid that the RC signal is affected.

#### **4.4.7 Autopilots**

The use of any onboard-sensed data to automatically move the control surfaces or to modify the aircraft geometry is prohibited.

#### **4.4.8 Automated Measuring Equipment**

To make automated measurements of your flights, we developed a small box with all the measurement equipment. It uses a Unilog GPS Logger 3 (<https://www.sm-modellbau.de/GPS-Logger-3>) to get the altitude and GPS Data. This logger is approved and tested by several model aircraft competitions. We conducted our own tests as well and were very satisfied with the stability of the GPS signal and logging accuracy.

The logger will be provided by the organizer and must be mounted in the aircraft by the team. Loosing of the logger will result in zero points for the flight.

It is your responsibility to fly in a way that the GPS receiver will point to the sky. Avoid steep bank angles (>40°) and high G-loads (>3-4g).

Loss of GPS-signal will not be a reason to get an additional new flight.

The measurement box shall be placed in the model with an unobstructed view of the sky.

We added two lines in the drawings to indicate an angle of 20° from the horizontal. You should not place any component over this line to ensure a good visibility of the sky.

The box will be handed to you before takeoff and must be given back after landing.

In case there is a problem with our logging equipment, the flight manager will give you a reflight.

You can find the size of the box in the Appendix: 6.3 Automated Measuring Equipment

The box will be screwed into your aircraft with two M3 screws. Every aircraft must have two M3 nuts directly under the box to safely and reliably mount the box. We suggest to use M3 drive-in nuts in the aircraft.

The box will have a maximum weight of 150g.

At the moment (July 2020) we are working on a radio link to get your live position to the ground. This means there will be a 434MHz, 868MHz (or 2.4GHz) transmitter and antenna attached to the box! There should not be any interference with your 2.4GHz RC-Radio, but please place your receiver antennas at some distance to the Measuring Equipment.

#### **4.4.9 Payload**

You are transporting small blood bags. We will fill them with water and some starch to reduce sloshing. We will provide 100g, 200g and 300g bags. The payload will predominantly consist of 300g bags. Only bags that are undamaged after unloading will be counted as transported payload, therefore take care of this precious resource. The total weight of the bags including the bag itself and fluid will be included in the payload calculation.

The payload must be fully enclosed within the aircraft's structure

We chose small bags to help you deal with sloshing, but you should still think about this problem.

Also note that the payload must not affect the center of gravity (CG) of the aircraft. -> The CG shall not change by different amounts of payload.

See section 6.4 for measurements of the size of the blood bags.

#### **4.4.10 Maximum take-off weight**

To stay within the regulations of the airfield, a maximum take-off mass of 20 kg must not be exceeded.

#### **4.4.11 Longitudinal Stability of the Aircraft**

To ensure a safe flight of your aircraft, the correct position of the CG is important.

Calculation of the correct CG has to be executed by using corresponding formulas. The chosen calculation method must be described in the preliminary report for review by the organizing committee.

To calculate the derivatives of the airfoils for the CG calculation, only the following methods or calculations by software are allowed:

- Wind tunnel measurements
- XFOIL
- XFLR5
- AVL
- Eppler

- Javafoil
- Other methods only after checking with the organizing committee.

A sufficient stability margin for stable flight has to be demonstrated in a calculation. The value of the intended stability margin must be delivered in the preliminary design report.

#### **4.4.12 Aircraft Production**

The aim of the Air Cargo Challenge is to learn and understand the challenges of the aircraft design process. Therefore, you must not only design the aircraft but you shall manufacture as many components of the airframe as possible by yourself. You will experience problems arising from your design decisions and learn from them. Especially the production of the wings shall be done by the team. Evidence that the manufacturing had been carried out by members of the participating team has to be provided (e.g. time lapse video recording, Photos,...)

Some components are specifically excluded from this rule. Please use reliable commercially available off the shelf parts for:

- RC components (transmitter, receiver, servos)
- Screws, fittings and connectors
- Powertrain (ESC, batteries)

#### **4.4.13 Proof of Flight**

An aircraft that has never flown before the competition and/or has no proof of flight will not be allowed to fly during the competition.

A proof of flight video shall be included in the Video presentation. (see also: 4.5.5)

#### **4.4.14 Technical Inspection**

During the technical inspection all aircrafts will be checked to meet this regulations and the minimum quality for a safe flight.

You will get a maximum of one hour time to build up your aircraft for the technical inspection. It has to be complete and ready for take-off, except for the batteries that are not connected until instructed and the payload that is provided on the flight days.

Inspection will comprise at least the following items:

- Dimensions
- Verification that all components are adequately secured to the vehicle
- Visual inspection of all electronic wiring to ensure adequate wires and connectors are used
- Verification that the propeller is attached safely
- Motor test
- RC-Check, range test with motor off and motor on
- Servo test
- Linkages (correct mechanics, backlash, strength)
- Payload installation ( minimum dimensions, fixation)
- Check of Center of Gravity
- Build quality
- Secure attachment of components

This list is not complete and we reserve the right to ground an aircraft we deem not airworthy.

#### **4.4.15 Static Load Test**

In addition to the technical inspection, there will be a static load test of the aircraft with payload before take-off.

A maximum of 2 team members are allowed to lift the aircraft on its wingtips by hand. (the thumb of the hand has to touch the outermost point of the wingtip) The aircraft has to withstand this load to be allowed for take-off.

## **4.5 DELIVERABLES**

The evaluation of the designs will be made in several disciplines:

1. Technical Report
2. Drawings
3. Video Presentation
4. Flight Competition.

All submissions must be in English. All submissions may be published on the internet or other media.

### **4.5.1 Preliminary Report (PR)**

The preliminary report is an update for the organizer. It consists of a written document that does not exceed one A4 page and eight additional pictures. It shall give a summary of the progress of the aircraft design and how you organized your team. It shall also show what is not developed yet and what difficulties you encountered.

Please don't forget to include your stability analysis formula as well as your aimed stability margin in the PR.

There will be no scoring on the Preliminary Report, but there are penalties if you miss to deliver it. Delivery is via e-mail in PDF format.

### **4.5.2 Technical Report (TR)**

The technical report sums up all your thoughts during the design of the aircraft and shows the final aircrafts with its details.

The TR may have up to 30 pages maximum (without attachments).

It must be printed in A4 format with font Calibri (or similar) size 12.

We will provide a template for the front page.

Each team has to send in three (3) complete hardcopies of the report as well as a PDF file via E-Mail. The delivered TR has to be bound in hardback.

To have a better comparability between the different reports, the report shall contain at least the following chapters:

- Introduction
- Project management (financial budget and time schedule)
- Aerodynamic design
- Structural design
- Payload prediction
- Outlook
- Drawings

More content is requested and necessary to get the full score for the Report.

The drawings have to be included in every report.

We accept delayed hardcopies without penalty **if** the identical digital version arrived on time (UTC) AND the hardcopies arrive at most one week later.

### **4.5.3 Drawings**

Each copy of the report must include a set of four detailed drawings of the aircraft. These drawings consist of A3 size sheets, printed on one side, properly folded, and bound with the report so that they can be analysed without separating them from the rest of the document.

One of the drawings must be a 3-view drawing of the aircraft using European projection, that is:

- front view at the top left corner
- top view below
- starboard view on the right of the front view

The views must contain the main aircraft dimensions (wingspan, wing chords, length and height, etc.). Below the starboard view, there must be a table containing other dimensional information such as relevant areas and/or volumes, used airfoil, etc.

The second drawing must be an isometric perspective view of the aircraft.

The third drawing shows the cargo bay, its location and dimensions, as well as the location of the RC receiver and the measuring equipment.

The fourth drawing must contain information that each team finds relevant.

Summary:

- 3-view drawing
- Isometric drawing
- Cargo bay, RC receiver position, position of measuring equipment
- Free choice

A standard scale for each drawing must be properly chosen. The 3-view and isometric perspective drawings may not display hidden lines. All dimensions must be in SI units except for linear lengths which shall be in millimetres and plain angles which shall be in degrees. All the drawings must have a label in the right bottom corner containing the team logo or university logo, the team's name and number, a short description and other pertinent information. The team shall send a fourth extra copy of the 3-view drawing without the report to be used during the dimensional inspection prior to the flight competition. This copy has to be sent with the report or a penalty of 10 points will be given. If the aircraft is changed after the technical report is sent in, a new copy with remarks identifying the changes has to be e-mailed to the organization committee.

### **4.5.4 Video Presentation (VP)**

All teams must deliver a video presentation (VP) including a proof of flight video.

The aim is to share the experience your team gained during one year of preparations. The presentation will be scored by our judges and put online by us before the competition to enable the exchange with other teams and the public. There is no specified way to realize the VP. (e.g. you may do a filmed standard presentation or some kind of product video) The team shall be present in the VP.

The video has a time limit of 15 minutes, including an approx. 1 minute proof of flight video.

Scoring will be based on:

- Clearness of information
- Articulation
- Presentation style
- accentuation of distinctive features of the design
- Elements about difficulties during the project, lessons learned for a future project, description of the methods used in the construction, etc. ...
- More needed for the full score

#### **4.5.5 Proof of Flight Video**

The proof of flight video must be included in the video presentation.

The video must be filmed from the ground, showing at least one complete take-off (incl. rolling) and sustained cruise flight condition.

#### **4.5.6 Poster**

Since there are no on-site presentations, every team will bring a poster (size A0, 841 mm × 1189 mm) with details of their design. These posters shall be easily understandable to give spectators of the event a glimpse of the work you put into this project. The poster shall at least contain the following:

- Header: ACC2021 logo (left side), Team number, Team name, 3-letter country code(right side; [https://en.wikipedia.org/wiki/ISO\\_3166-1\\_alpha-3](https://en.wikipedia.org/wiki/ISO_3166-1_alpha-3))
- Team/University logo
- Basic aircraft parameters (span, wing area,...)
- Image, isometric view or rendering of the entire plane to identify it during the competition.
- Special features of the aircraft

#### **4.5.7 Deliverables Scoring**

The following points can be achieved:

- Report:  $S_{\text{Report}}$  = max. 200 points
- Drawings:  $S_{\text{Drawings}}$  = max. 50 points
- Video Presentation:  $S_{\text{Video}}$  = max. 100 points

Points are given by our jury.

## 4.6 COMPETITION

### 4.6.1 Flightfield

Medical aid is not always needed at perfectly equipped airfields. Your aircraft needs to withstand harsher environments.

Therefore our take-off and landing field is made of grass. Detailed pictures of the runway will be published in the near future. It will be lawn moved before the competition.

### 4.6.2 Flight area

You can find some pictures of the airfield in the appendix.

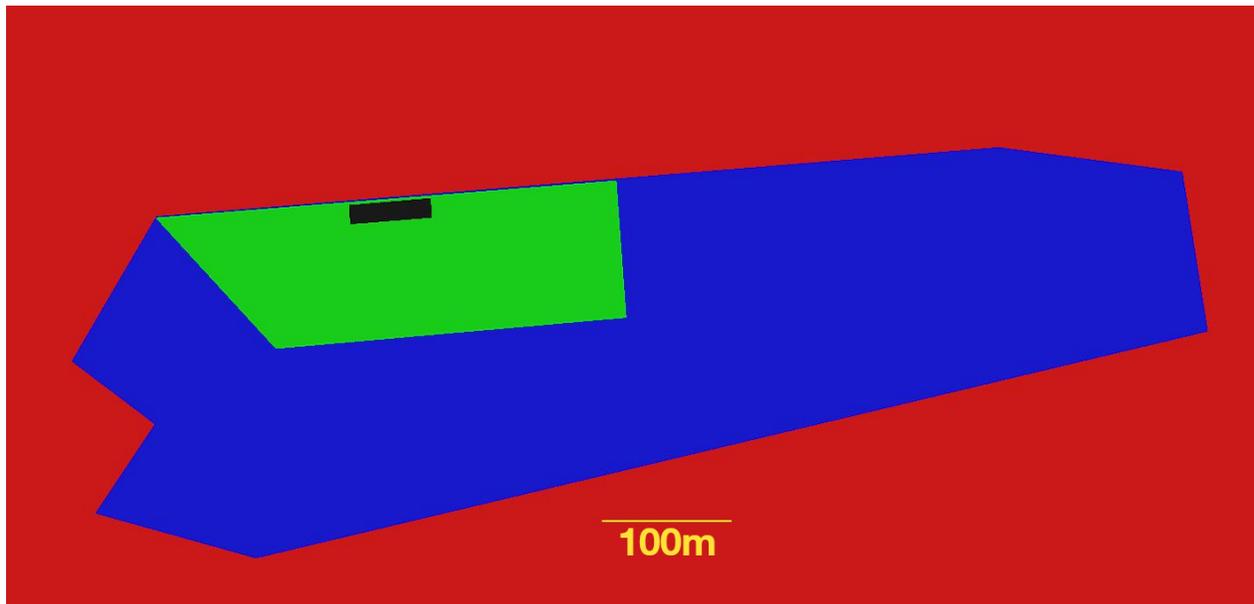


Figure 1: Flight Area: RED: No-Fly-Zone; BLUE: Flight area; GREEN: Landing field; BLACK: grass runway

### 4.6.3 Bad weather

The contest will be interrupted if the wind, measured at approx. 2 metres above the ground at the starting line, is stronger than 9 m/s for at least 20 seconds. (8m/s if the wind is more than 45° from the starting direction)

We will try to avoid rain, but you have to be prepared for high humidity conditions or even light rain.

The flight manager can interrupt the competition earlier if there are safety concerns.

### 4.6.4 Protest

The teams have the right to protest against the decisions made by the organizing committee. The current regulation and the decisions of the judges cannot be the target of any protests.

The protests must be presented in writing in English to the judges by the team's leader. The organizing committee is available to accept any suggestions or criticism aiming at improving any aspect of the competition. We remind you that unjustified protests will end in a penalty.

#### 4.6.5 Pilot, Helper and Flight Manager

The pilot is allowed to have one helper with him on the runway. All other team members have to be in the safety area during the flight.

The pilot is required to follow the German laws. This includes, that he must not be under the influence of alcohol, drugs or other substances.

There will be a flight manager directly next to the pilot. He is the authority on the field and helps you to stay within the flight area. There will be no take-off attempt without his specific call. The flight manager is also allowed to demand an abort of flight and immediate landing.

#### 4.6.6 Overview of entire flight task

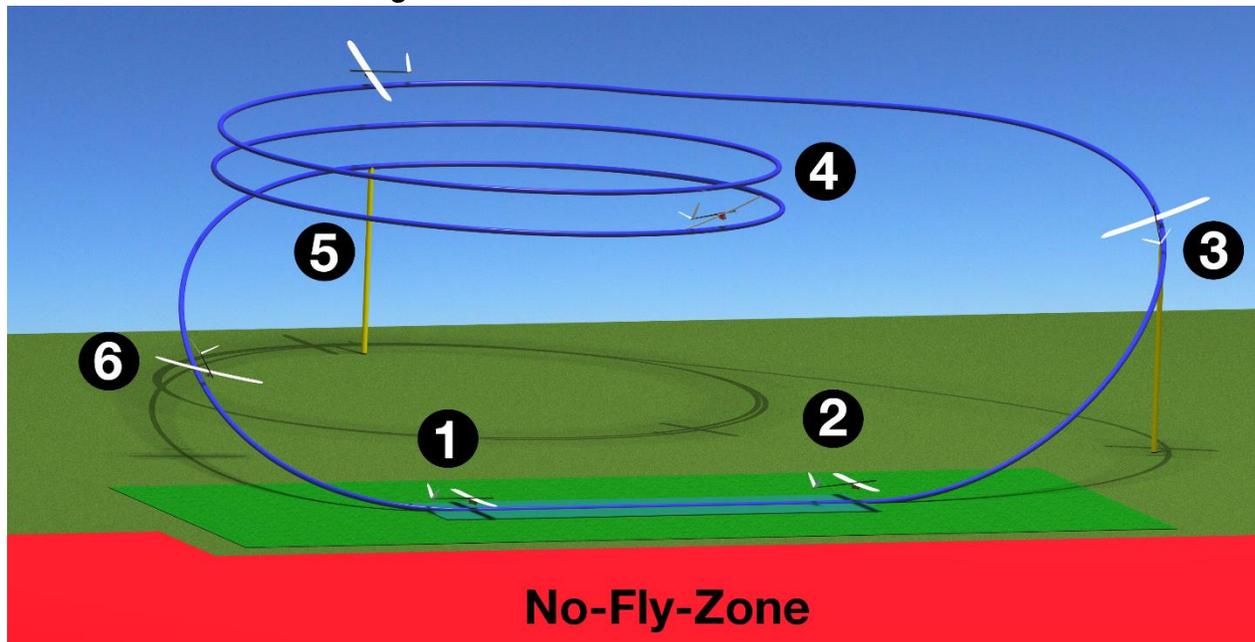


Figure 2: Graphic of entire flight task

1. Take-off
2. Climb
3. After 60 seconds -> Climb assessment over, start of 120 seconds distance flight
4. Fly at will
5. End of distance flight -> Distance assessment over
6. Safe landing -> Payload assessment over

After take-off with your payload you will climb as high as possible within 60 seconds. The measuring equipment will automatically log the reached altitude. Now the distance task starts. You have to fly as far as possible within 120 seconds. This is logged as well. After that you have to perform a safe landing.

#### 4.6.7 Take-off

The grass runway has 60m length. (Approximately 15m width, wait for details)

The entire aircraft has to be inside the runway and no team member is allowed to touch the aircraft after line-up.

If you touch anything outside this runway during take-off, there will be a red flag indicating that

you violated the take-off distance. In that case you are allowed to return your aircraft to the start line with a maximum of three team members and try again as soon as the helpers are in the safety area.

You have three minutes to complete your take-off.

#### **4.6.8 Restricted areas**

If you land or fly outside the flight area, the flight will be scored with zero points.

As safety for participants and visitors is our highest priority there will be a penalty up to disqualification if any person is endangered by the aircraft. Please inform your pilots that highest priority is the wellbeing of people, not the aircraft.

#### **4.6.9 Flight Pattern**

You may fly at will during your entire flight time.

You must ensure to stay within the flight area. The bounds will be indicated to you by the flight manager during flight and in the pilots briefing before the competition.

#### **4.6.10 Landing**

The landing has to take place in the landing area as shown in the map.

Please note that the grass outside the runway may be much higher.

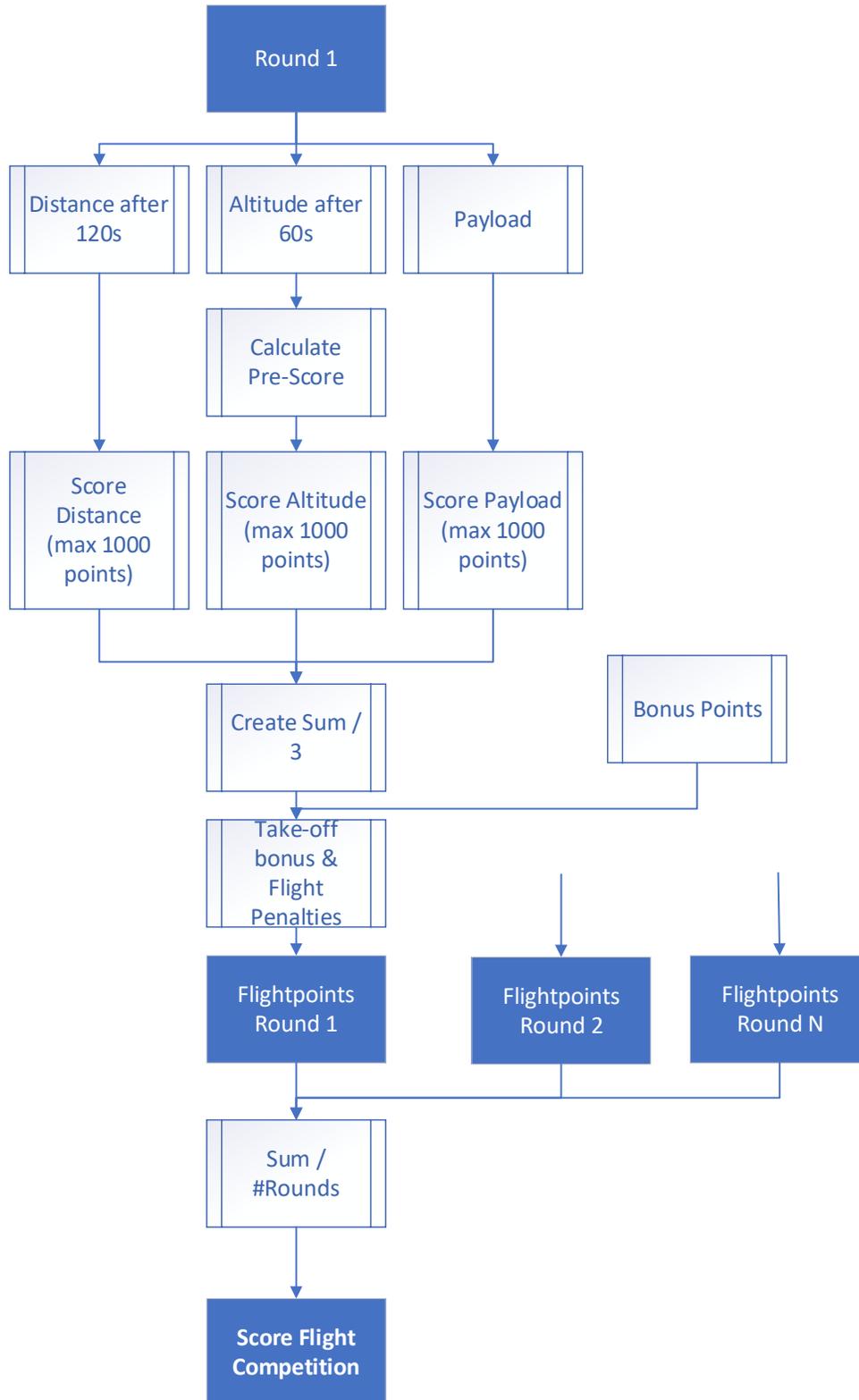
If you lose any parts during landing (status after landing not equal to the status before take-off) you will get a deduction to your score.

#### **4.6.11 Minimum flight altitude**

The minimum flight altitude for the distance flight is 10m. If you fly below this, the distance will not be counted.

## 4.7 FLIGHT COMPETITION SCORING

### 4.7.1 Overview



#### 4.7.2 Partial Scores

In reality you don't get a fixed formula to assess your aircraft. You have to do some research of competitors, comparable existing aircrafts or the physical effects that limit the performance of aircrafts.

We will fly several rounds. Every team gets the chance to fly once during each round.

Partial scores will score the flight performance for each round independently for three features:

1. Payload transported during the flight
2. Travelled distance within two minutes
3. Altitude reached 60 seconds after take-off

The team with the best result in each category will get 1000 points. The other teams partially less.

In the end, all achieved points will be added up for the ranking.

#### 4.7.3 Payload Scoring

The "Score Payload" for each flight is determined as follows:

$$S_{payload} = 1000 \times \frac{P_{team}}{P_{max}}$$

$P_{team}$  = Payload transported during your flight

$P_{max}$  = Maximum Payload by any team during this round

#### 4.7.4 Distance Scoring

The "Score Distance" for each flight is determined as follows:

$$S_{distance} = 1000 \times \frac{D_{team}}{D_{max}}$$

$D_{team}$  = Distance travelled during your flight

$D_{max}$  = Maximum distance travelled by any team during this round

#### 4.7.5 Altitude Scoring

We want you to fly in a safe altitude but not violating our flight field restrictions. (Minimum 10m, maximum 120m altitude) This is why this part of the scoring is a little bit different.

At first we will calculate a “Pre-Score”, based on a formula. Based on this Pre-Score we will apply the partial scoring as above.

##### Pre-Score Altitude

$$PS_{altitude} = a * h_{60s}^4 + b * h_{60s}^3 + c * h_{60s}^2 + d * h_{60s} + e$$

$h_{60s}$  = The altitude of your aircraft 60 seconds after take-off

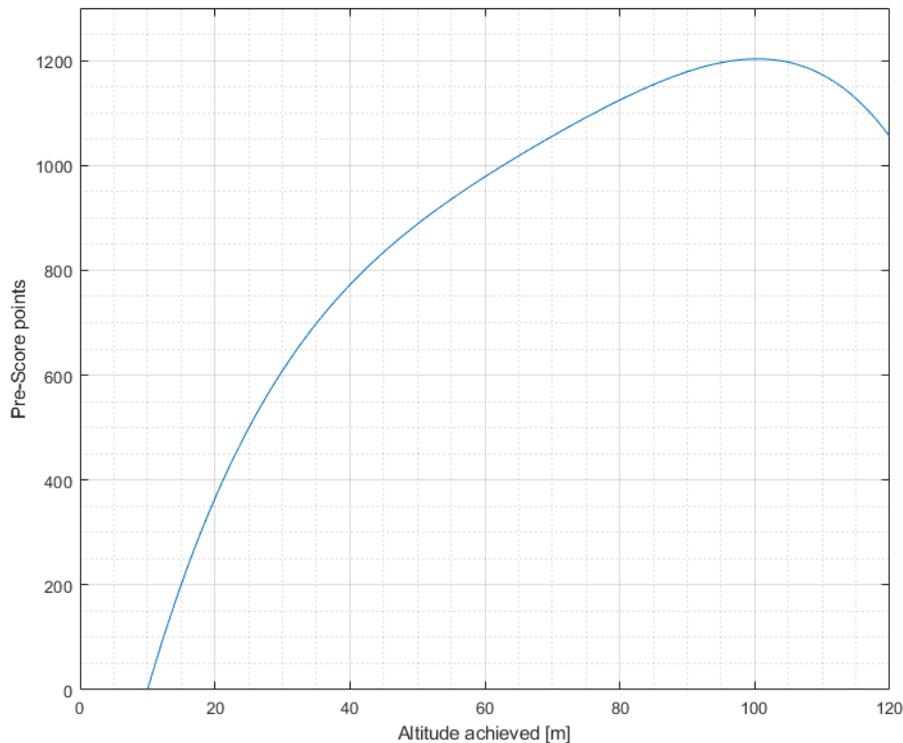
a = -3.92e-5 [Points/m<sup>4</sup>]

b = 1.08e-2 [Points/m<sup>3</sup>]

c = -1.156 [Points/m<sup>2</sup>]

d = 64.2 [Points/m]

e = -537 [Points]



##### Score Altitude

$$S_{altitude} = 1000 \times \frac{PS_{altitude,team}}{PS_{altitude,max}}$$

$PS_{altitude}$  = Pre-Score Altitude achieved during your flight

$PS_{altitude,max}$  = Maximum Pre-Score Altitude achieved by any team during this round

#### 4.7.6 Definition Flight Time

The flight time starts with your aircraft reaching 5 km/h GPS-speed in the logged data. After 60 seconds, the altitude will be recorded and the 120 seconds for the distance flight start. After the additional 120 seconds are over, the travelled distance during this time is recorded. This results in a total flight time of 180 seconds plus time for landing. (Keep in mind you may need more than one or two tries for landing)

#### 4.7.7 Loading Time

For each flight the team has to put the payload into the aircraft. The shorter the amount of time a team needs for loading the payload, the more points can be gained. The aircraft shall be prepared for take-off completely before the loading. (Except plugging in the main battery) After the payload is mounted, no more changes to the aircraft shall be made. (Except plugging in the main battery)

The relationship is the following:

$$B_{Loading} = \begin{cases} 60 \times \left(1 - \frac{t}{120s}\right) & \text{for } t < 120s; \\ 0 \text{ points} & \text{for } t \geq 120s \end{cases}$$

t = time needed to load the payload

#### 4.7.8 Unloading Time

After the flight, the main battery is disconnected and the aircraft is transported to a safe location on the ground by the team. There will be an additional unloading bonus to get the payload back out of the plane fast.

$$B_{unloading} = \begin{cases} 60 \times \left(1 - \frac{t}{120s}\right) & \text{for } t < 120s; \\ 0 \text{ points} & \text{for } t \geq 120s \end{cases}$$

t = time needed to unload the payload

#### 4.7.9 Payload Prediction Bonus

A payload prediction must be calculated as a function of the air density in the technical report. A linear approximation of the following form must be used:

$$\text{Predicted payload [kg]} = a \times \text{air density} \left[ \frac{\text{kg}}{\text{m}^3} \right] + b$$

The formula and a graph must be included in the technical report. The payload prediction bonus will be determined according to the following formula:

$$B_{Prediction} = 50 \times \left(1 - \left| \frac{\text{achieved payload}}{\text{predicted payload}} - 1 \right| \right)$$

No negative bonus points will be given.

Both achieved payload and predicted payload have to be positive.

The predicted payload is the value obtained from the chart of payload prediction. The actual payload is the payload achieved for the flight.

#### 4.7.10 Take-off Bonus

If your team decides to only use 40 meters instead of the available 60 meters of runway you will get an additional 10% bonus to your flight points.

You have to announce this option together with you payload before the round starts. All rules apply for 40m instead of 60m, e.g. if you can't start within 40m the flight is invalid and you may try again if the remaining time allows it.

$$B_{take-off} = \begin{cases} 0 & \text{for violating runway limit} \\ 1 & \text{for 60m runway} \\ 1.1 & \text{for 40m runway option} \end{cases}$$

#### 4.7.11 Flight Penalties

If any part of the aircraft gets lost during the flight attempt, the flight will be scored with zero points due to safety concerns. "Lost" means that a part has no more physical connection to the aircraft.

If you are flying below 10m (except for take-off and landing) or over 120m altitude during the flight you will receive zero points for the round.

$$P_{flight} = \begin{cases} 1 & \\ 0 & \text{if any parts are lost or flight altitude was under 10m or over 120m} \end{cases}$$

#### 4.7.12 Score for one Round

Using the results from 4.7.3 - 0 we now calculate the total points for the team for one round

$$S_{Round,N} = \left( \frac{S_{payload} + S_{distance} + S_{altitude}}{3} + (B_{Loading} + B_{Unloading} + B_{Prediction}) \right) * B_{take-off} * P_{flight}$$

$S_{payload}$	= Partial score Payload during the flight (4.7.3)
$S_{distance}$	= Partial score Distance during the flight (4.7.4)
$S_{altitude}$	= Partial score Altitude during the flight (4.7.5)
$B_{Loading}$	= Bonus Points for Loading Time (4.7.7)
$B_{Unloading}$	= Bonus Points for Unloading Time (4.7.8)
$B_{Prediction}$	= Bonus Points for Payload Prediction (4.7.9)
$B_{take-off}$	= Bonus Points for short take-off (4.7.10)
$P_{flight}$	= Penalty factor if parts are lost or altitude is too low (4.7.11)

(Therefore the total points of one round can never be higher than 1287 points.)

#### 4.7.13 Score for the Flight Competition

$$S_{FC} = \frac{\sum_{N=1}^R S_{Round,N}}{R}$$

$S_{\text{Round},N}$  = Score of the team for Round N (4.7.12)  
R = Number of rounds minus omitted rounds

(Therefore the total points of the flight competition can never be higher than 1287 points.)

In case there are more than 3 rounds, the teams' round with the lowest score will be omitted.

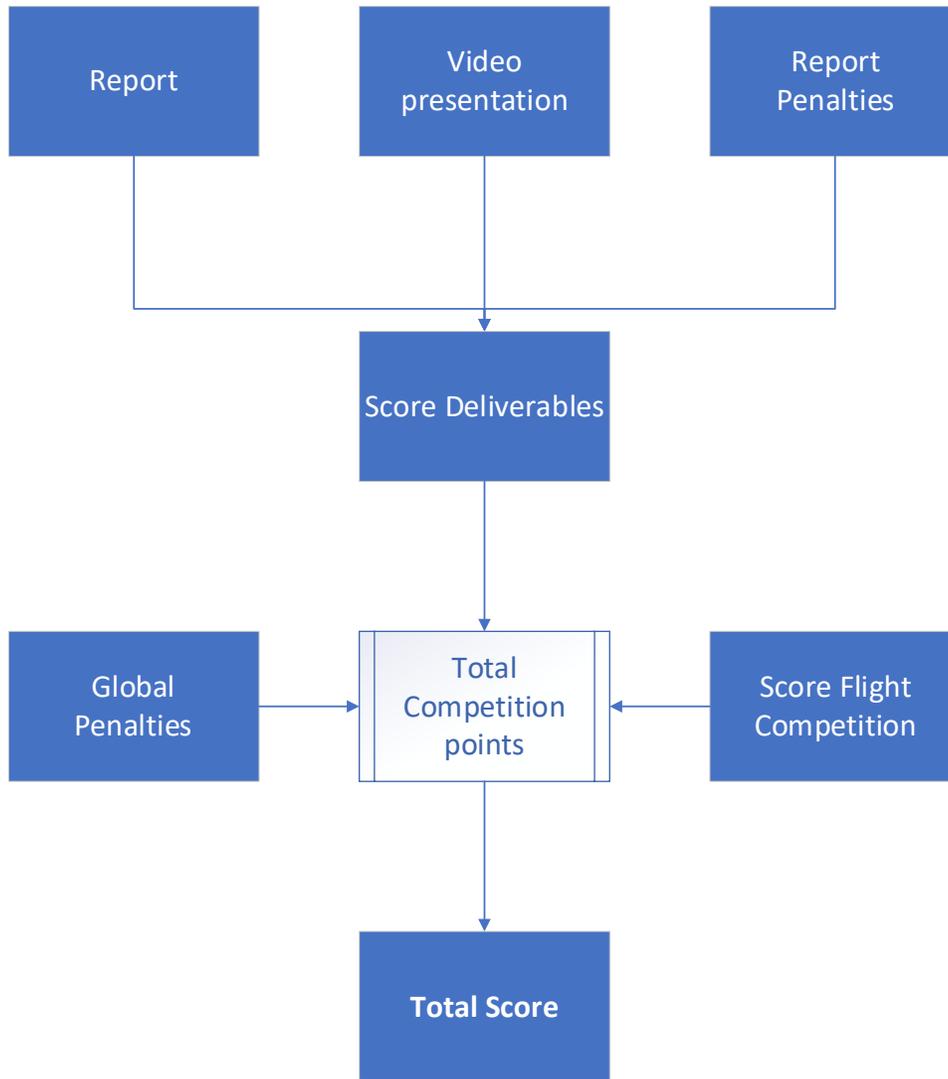
In case there are more than 6 rounds, the teams' two rounds with the lowest score will be omitted.

## 4.8 GLOBAL PENALTIES

These Points will be deducted from your final competition score.

Delay in delivering Preliminary report	30 points per day, max. 100 points
Poster missing	100 points
Delay in delivering technical report/drawings	30 points + 30 points per day
Delay or not being present at technical inspection. (e.g. over 60 min set-up-time)	50 points
Delays during competition	5 points per minute
Chart or equation of payload vs. air density is missing	no payload prediction bonus
Replacement of parts without notifying the organisation committee	50 points
Extra version of drawings is missing	50 points
Disregard of regulations	Disqualification
Video for proof of flight, delay	10 points per day
Changes of the aircraft to the technical report	Defined for each case
Flying over spectator area	200 points penalty + Flight with 0 Points 2 <sup>nd</sup> offender: disqualification
Flying outside the Flight area	200 points penalty + Flight with 0 Points 2 <sup>nd</sup> offender: disqualification
Disregard of flight manager/Jury/Organizing committee	200 points penalty up to disqualification
Unjustified protest (the jury does not agree with your protest)	First time: 20 points Next times: 100 points

## 4.9 TOTAL SCORE / FINAL RANKING



All given points will go into the final ranking

$$S_{total} = S_{FC} + S_{Report} + S_{Drawings} + S_{Video} - \sum Global Penalties$$

$S_{FC}$  = Score of the team during the flight competition (4.7.13)

$S_{Report}$  = Score of the Final Report (4.5.7)

$S_{Drawings}$  = Score of the Drawings (4.5.7)

$S_{Video}$  = Score of the Video Presentation (4.5.7)

Global Penalties = Sum of all global Penalties (4.8)

(A maximum of 1637 points can be achieved in the entire competition theoretically.)

The final ranking is based on this score.

## 5 FINAL REMARKS

---

We hope you enjoyed the new regulations. If you have any questions, feel free to contact us!

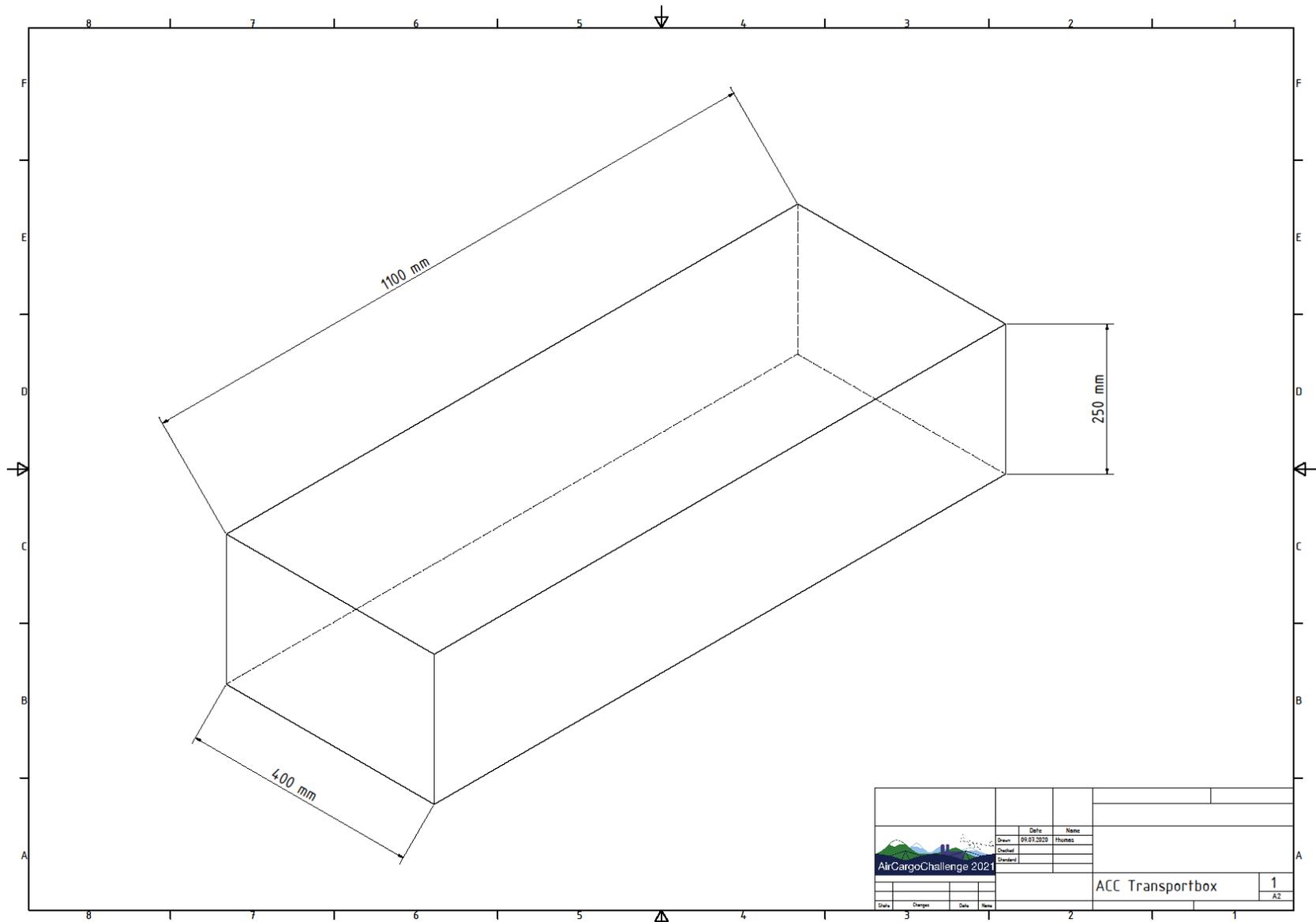
For now we wish you good luck, stay safe and let's have a great time in Munich in the summer of 2021!

-Your AkaModell Munich team

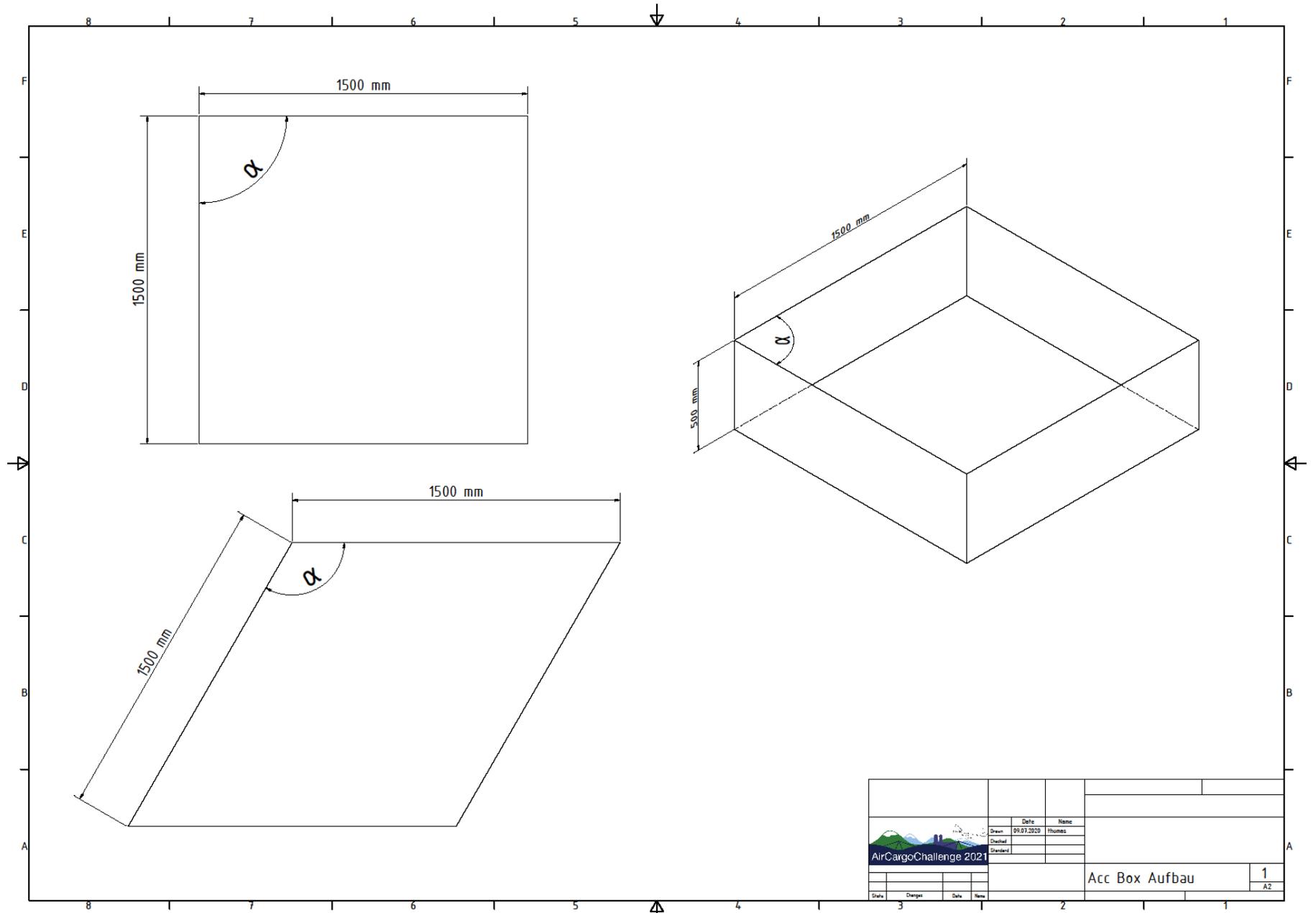


# 6 APPENDIX

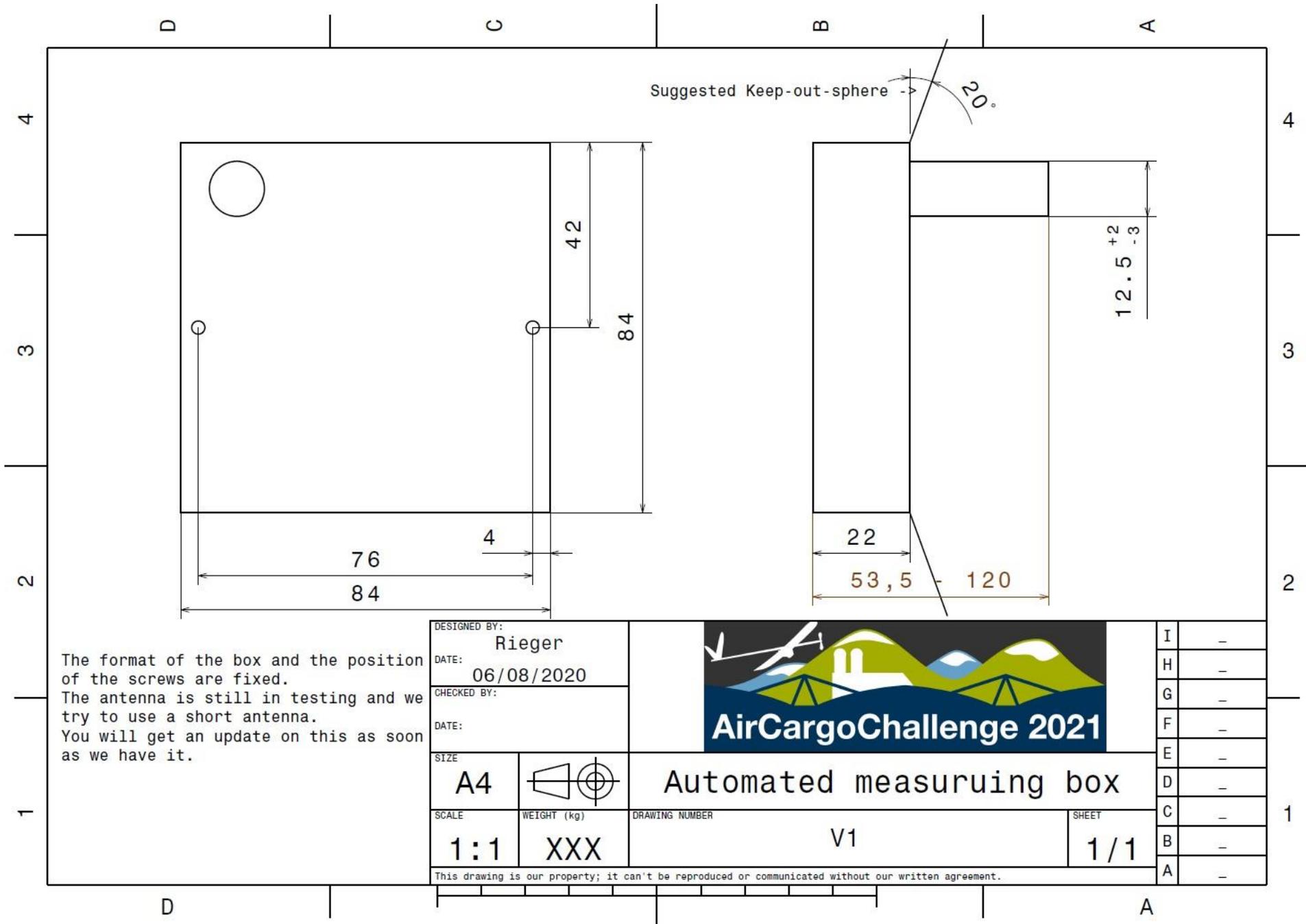
## 6.1 TRANSPORTATION BOX



## 6.2 LIMITING BOX IN SET-UP STATE



### 6.3 AUTOMATED MEASURING EQUIPMENT



The format of the box and the position of the screws are fixed.  
 The antenna is still in testing and we try to use a short antenna.  
 You will get an update on this as soon as we have it.

DESIGNED BY: <b>Rieger</b>	
DATE: <b>06/08/2020</b>	
CHECKED BY:	
DATE:	
SIZE <b>A4</b>	
SCALE <b>1:1</b>	WEIGHT (kg) <b>XXX</b>



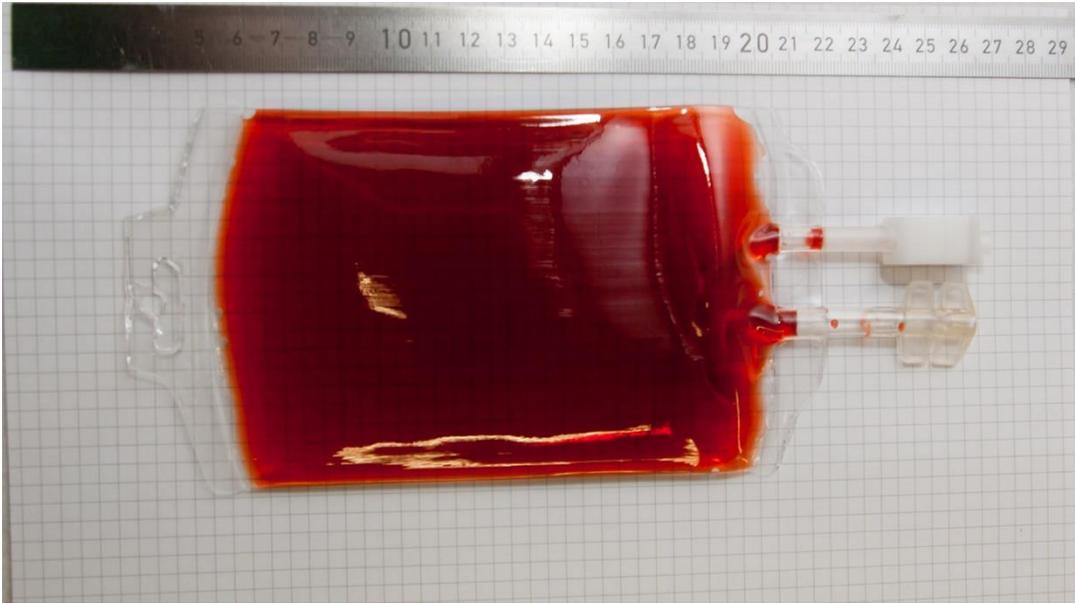
<b>Automated measuring box</b>	
DRAWING NUMBER <b>V1</b>	SHEET <b>1/1</b>

I	-
H	-
G	-
F	-
E	-
D	-
C	-
B	-
A	-

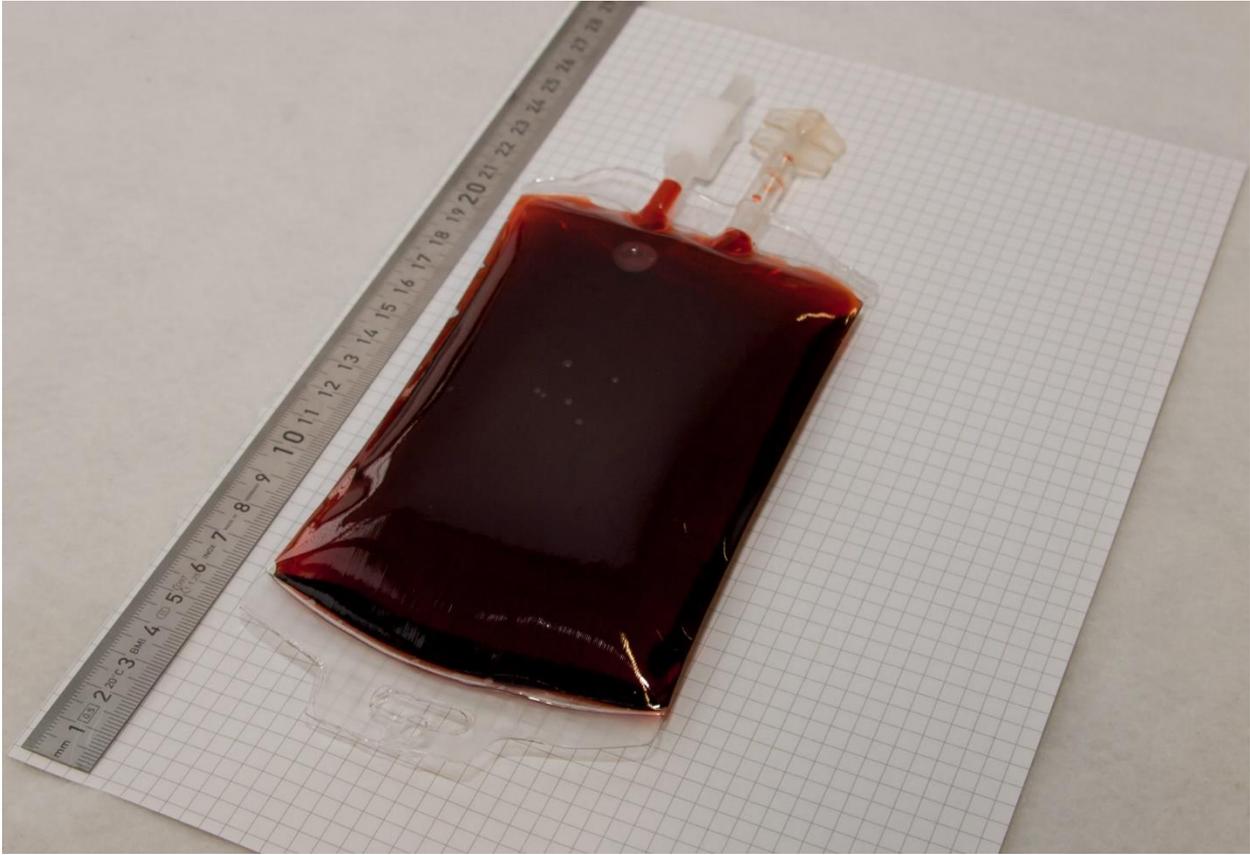
This drawing is our property; it can't be reproduced or communicated without our written agreement.

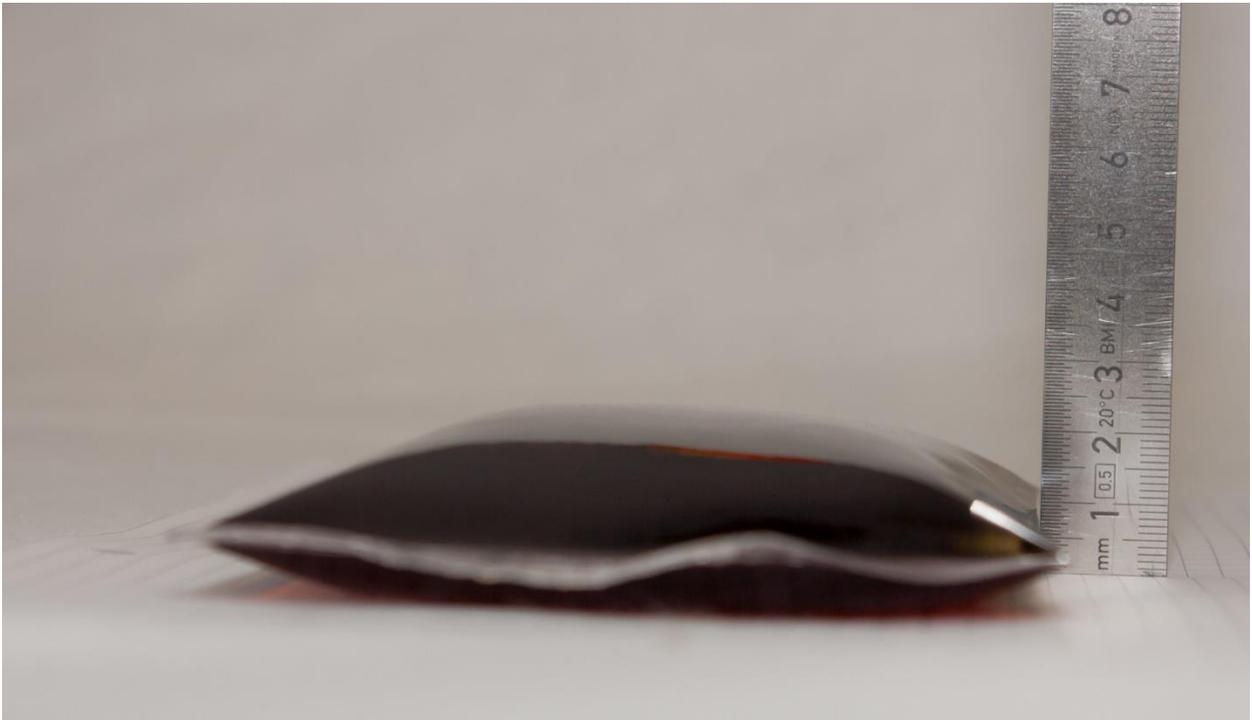
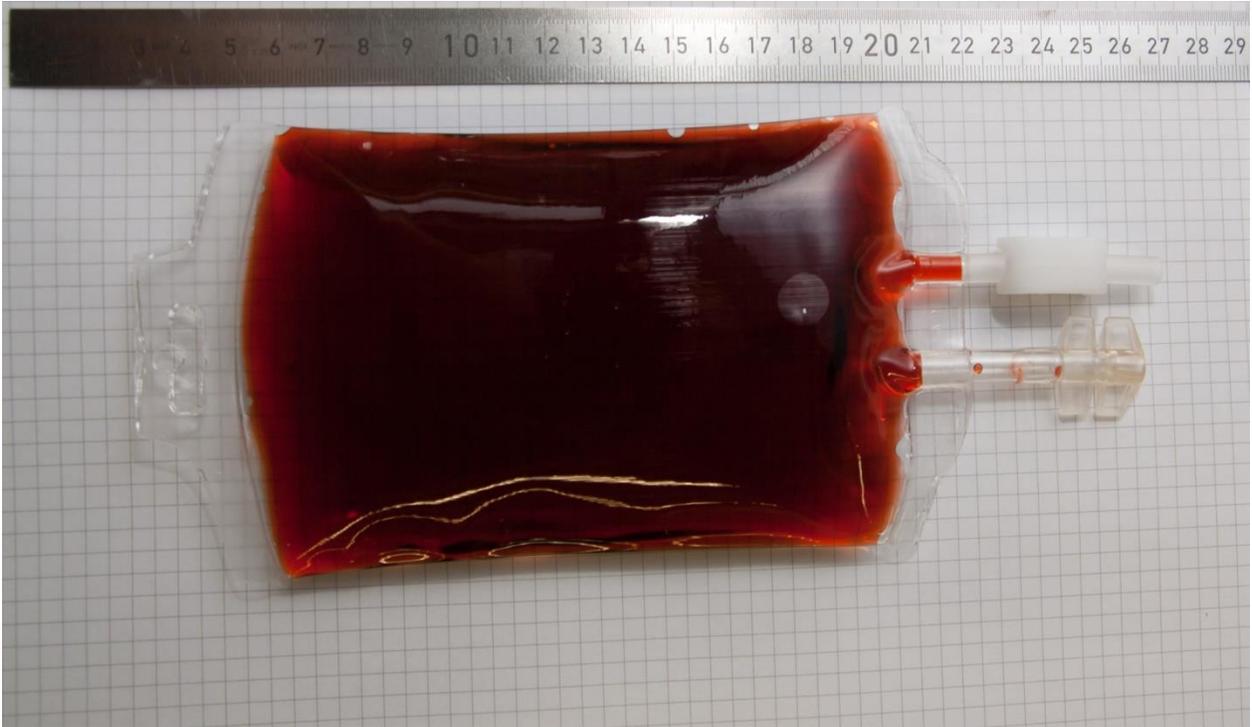
**6.4 PAYLOAD PHOTOS / DIMENSIONS**

100g

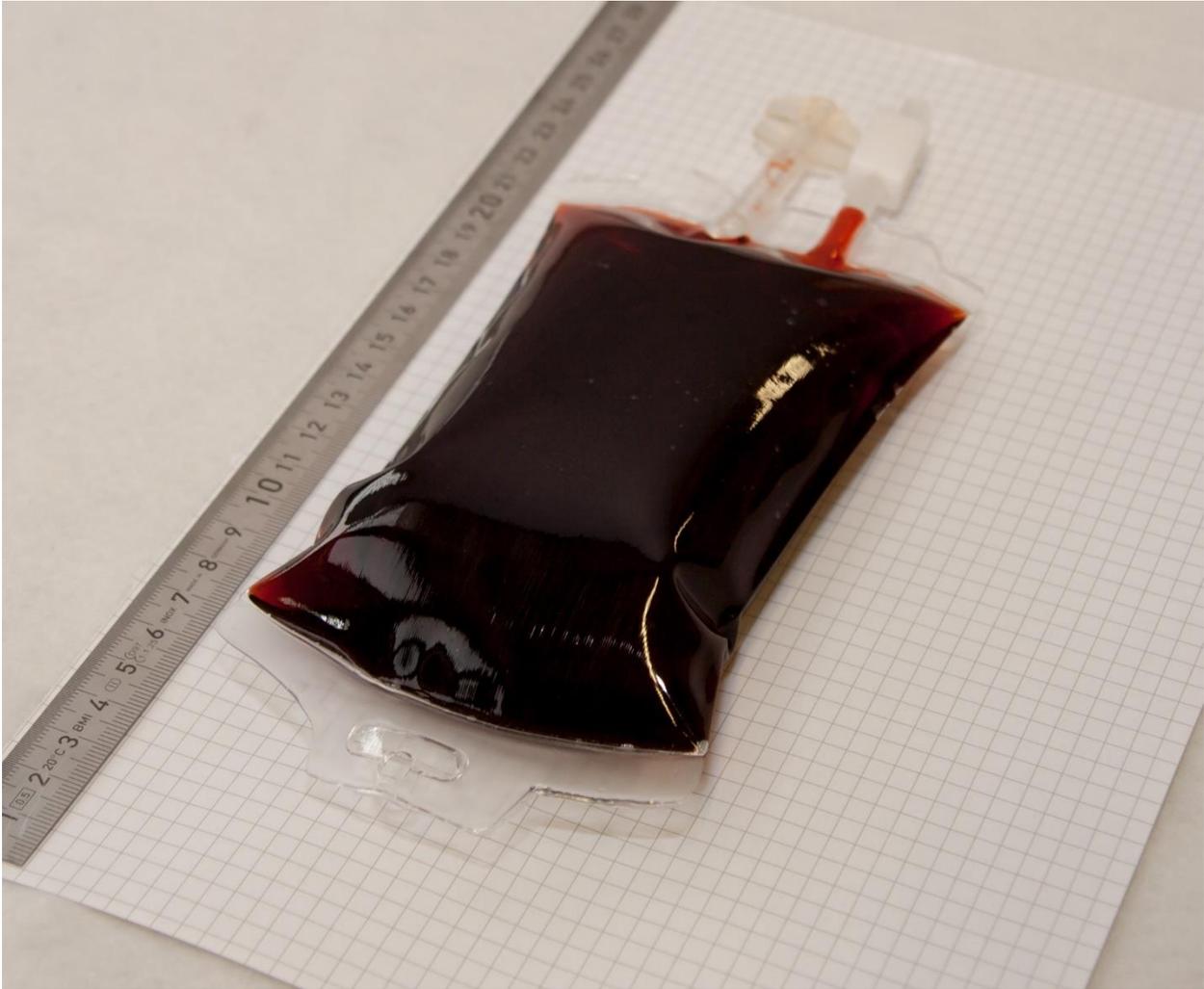


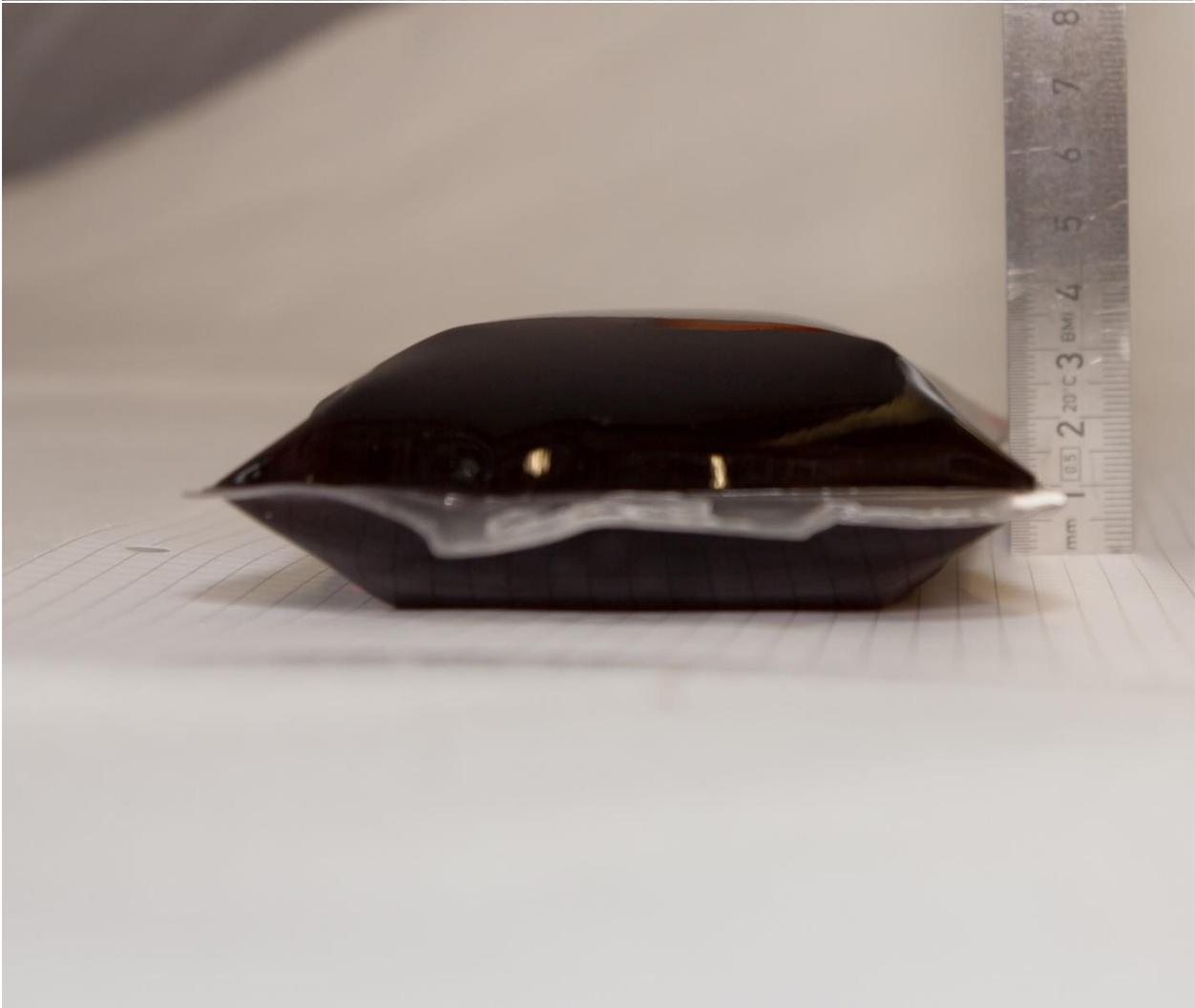
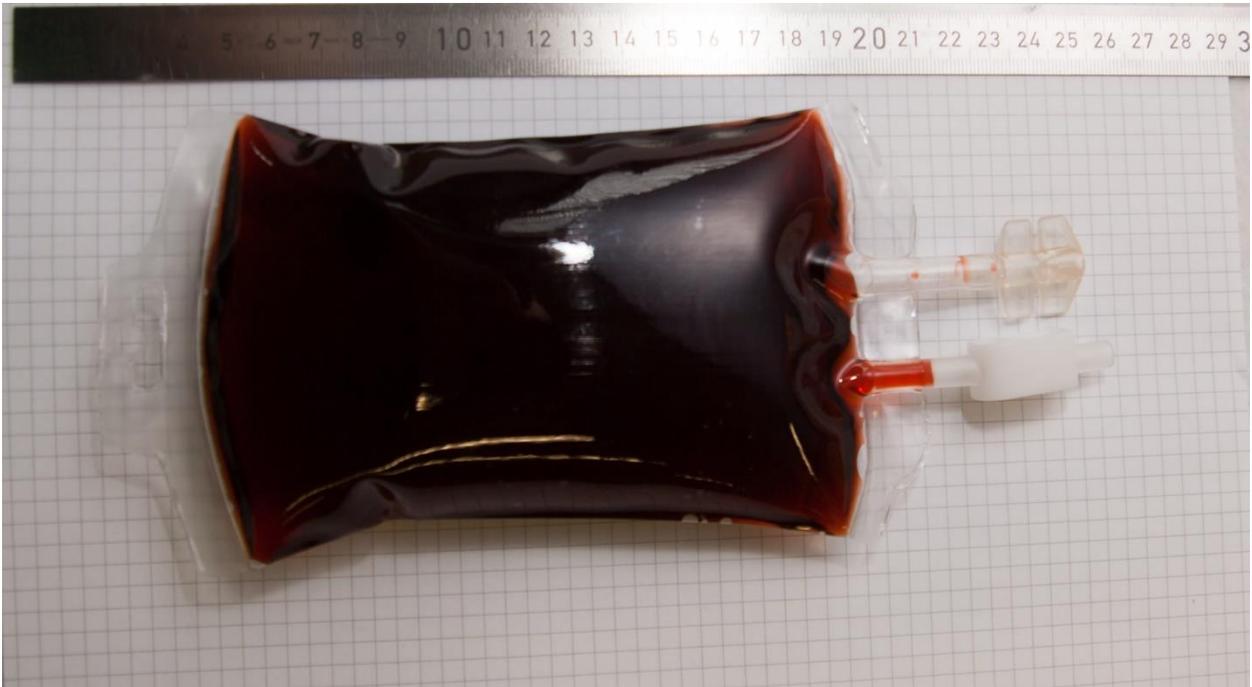
200g





300g





## 6.5 FLIGHTFIELD PHOTOS

These photos are intended to give you a first impression. We will provide better pictures later.



*Figure 3: Direction west (Starting or Landing direction, End of runway)*



*Figure 4: Direction south*



*Figure 5: Direction East (Starting or Landing direction)*